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TAXOL ENHANCER COMPOUNDS

RELATED APPLICATIONS

This application is a continuation of U.S. Patent Application No. 10/193,639, filed July 10, 2002, which claims the benefit of U.S. Provisional Application No. 60/304,252, filed July 10, 2001, and U.S. Provisional Application Serial No. 60/361,936, filed March 6, 2002. The entire teachings of these three applications are incorporated herein by reference.

BACKGROUND OF THE INVENTION

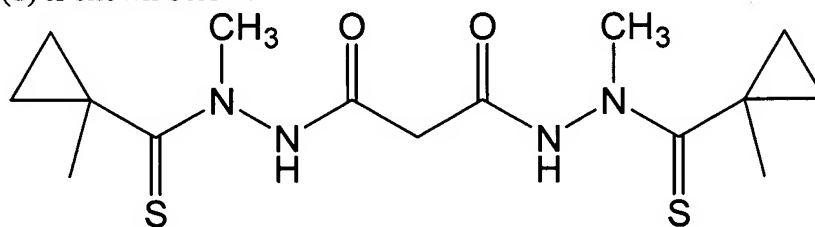
20 Many new drugs are now available to be used by oncologists in treating patients with cancer. Often, tumors are more responsive to treatment when anti-cancer drugs are administered in combination to the patient than when the same drugs are administered individually and sequentially. One advantage of this approach is that the anti-cancer agents often act synergistically because the tumors cells are attacked simultaneously
25 with agents having multiple modes of action. Thus, it is often possible to achieve more rapid reductions in tumor size by administering these drugs in combination. Another advantage of combination chemotherapy is that tumors are more likely to be eradicated completely and are less likely to develop resistance to the anti-cancer drugs being used to treat the patient.

30 One serious limitation of combination chemotherapy is that anti-cancer agents generally have severe side effects, even when administered individually. For example, the well known anti-cancer agent taxol causes neutroperia, neuropathy, mucositis,

anemia, thrombocytopenia, bradycardia, diarrhea and nausea. Unfortunately, the toxicity of anti-cancer agents is generally additive when the drugs are administered in combination. As result, certain types of anti-cancer drugs are generally not combined. The combined toxic side-effects of those anti-cancer drugs that are administered simultaneously can place severe limitations on the quantities that can be used in combination. Often, it is not possible to use enough of the combination therapy to achieve the desired synergistic effects. Therefore, there is an urgent need for agents which can enhance the desirable tumor attacking properties of anti-cancer agents without further increasing their undesirable side-effects.

SUMMARY OF THE INVENTION

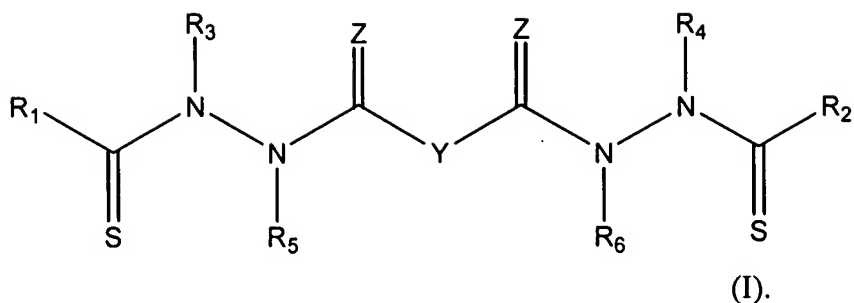
It has now been found that certain bis[thio-hydrazide amide] compounds significantly enhance the anti-cancer activity of taxol. For example, Compound (1) was used in combination with taxol (Paclitaxel) to treat tumors induced in nude mice from the human breast tumor cell line MDA-435. The tumor volume was about five fold less after 24 days of treatment in mice which had been administered 5 mg/kg of taxol and 25 mg/kg of Compound (1) than in mice which had only been administered 5 mg/kg of taxol or in mice which had only been administered 50 mg/kg of Compound (1) (Example 7). These results are shown graphically in Figure 1. The structure of Compound (1) is shown below:



Compound (1)

It has also been found that these bis[thio-hydrazide amide] compounds have minimal toxic side effects. For example, the mice treated with taxol and Compound (1) showed little if any weight loss over the treatment period (see Figure 2). Based on these results, novel compounds which enhance the anti-cancer activity of taxol, pharmaceutical compositions comprising these compounds and methods of treating a subject with cancer are disclosed herein.

One embodiment of the present invention is a compound represented by the Structural Formula (I):



Y is a covalent bond, a phenylene group or a substituted or unsubstituted straight chained hydrocarbyl group. In addition, Y, taken together with both $>C=Z$ groups to which it is bonded, is a substituted or unsubstituted aromatic group. Preferably, Y is a covalent bond or $-C(R_7R_8)-$.

R_1 is an aliphatic group, a substituted aliphatic group, a non-aromatic heterocyclic group, or a substituted non-aromatic heterocyclic group.

R_2 - R_4 are independently -H, an aliphatic group, a substituted aliphatic group, a non-aromatic heterocyclic group, a substituted non-aromatic heterocyclic group, an aryl group or a substituted aryl group, or R_1 and R_3 taken together with the carbon and nitrogen atoms to which they are bonded, and/or R_2 and R_4 taken together with the carbon and nitrogen atoms to which they are bonded, form a non-aromatic heterocyclic ring optionally fused to an aromatic ring.

R_5 - R_6 are independently -H, an aliphatic group, a substituted aliphatic group, an aryl group or a substituted aryl group.

R_7 and R_8 are each independently -H, an aliphatic or substituted aliphatic group, or R_7 is -H and R_8 is a substituted or unsubstituted aryl group, or, R_7 and R_8 , taken together, are a C2-C6 substituted or unsubstituted alkylene group.

Z is =O or =S.

In one aspect, R_1 and R_2 in the compound represented by Structural Formula (I) are not both C1-C5 alkyl (preferably not both methyl) when Y is $-C(R_7R_8)-$. R_3 and R_4 are both phenyl and R_5 - R_8 are all -H.

Another embodiment of the present invention is a pharmaceutical composition comprising a pharmaceutically acceptable carrier or diluent and a compound represented by Structural Formula (I). Preferably, the pharmaceutical composition comprises an effective concentration of the compound.

Yet another embodiment of the present invention is a method of treating a subject with cancer. The method comprises administering to the subject an effective amount of taxol or a taxol analog and an effective amount of a compound represented by Structural Formula (I).

The disclosed compounds increase the anti-cancer activity of taxol and taxol analogs. In addition, these compounds have minimal toxic side-effects. Consequently, it is possible to increase the effectiveness of taxol and analogs thereof when used in combination with the disclosed compounds, even when approaching the highest tolerated doses of taxol. Thus, it is expected that combination therapy with the compounds of the present invention will provide improved clinical outcomes for patients with cancers that are being treated with taxol. By co-administering the disclosed compounds with taxol, it is also possible to achieve the same therapeutic effectiveness previously achieved with higher doses of taxol, thereby reducing the side-effects and improving the quality of life for the patient.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a graph showing the average tumor volume in milliliters over time (in days) in nude mice treated with vehicle (●); Compound (1) (25 mg/kg) (◆); Paclitaxel (15 mg/kg) (■); or Compound (1) (25 mg/kg) and Paclitaxel (15 mg/kg) (□). The tumors were generated from the human breast tumor cell line MDA-435.

Figure 2 is a graph showing the percent weight change over time in nude mice treated with vehicle (●); Compound (1) (25 mg/kg) (◆); Paclitaxel (15 mg/kg) (■); or Compound (1) (25 mg/kg) and Paclitaxel (15 mg/kg) (□). The mice were being treated for tumors generated from the human breast tumor cell line MDA-435.

Figure 3 is the structure of taxol (Paclitaxel)

Figure 4 is the structure of taxotere (Docetaxol)

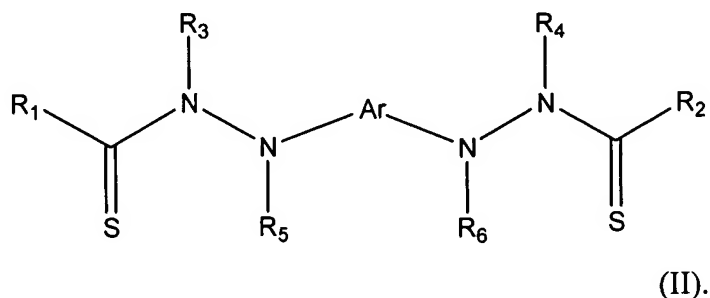
Figures 5-25 are each the structure of a taxol analog.

Figure 26 is the structure of a polymer comprising a taxol analog group pendent from the polymer backbone. The polymer is a terpolymer of the three monomer units shown.

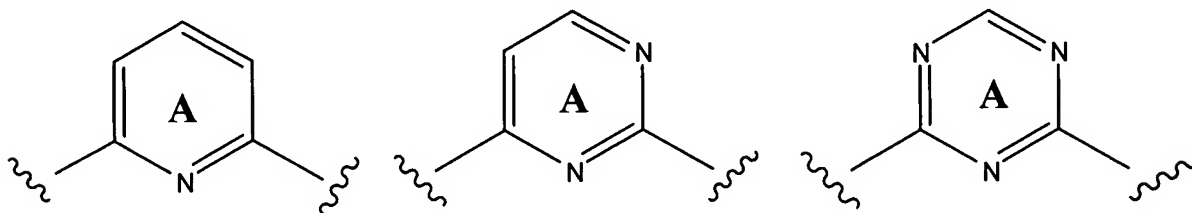
DETAILED DESCRIPTION OF THE INVENTION

The present invention is directed to compounds represented by Structural Formula (I) and the use thereof as taxol enhancers in the treatment of cancer. In aspect, Y is a covalent bond or a substituted or unsubstituted straight chained hydrocarbonyl group. In addition, Y, taken together with both $>C=Z$ groups to which it is bonded, is a substituted or unsubstituted aromatic group (preferably, a covalent bond or $-C(R_7R_8)-$); and R_1 is an aliphatic group or a substituted aliphatic group, R_2-R_4 are independently -H, an aliphatic group, a substituted aliphatic group, an aryl group or a substituted aryl group, or R_1 and R_3 taken together with the carbon and nitrogen atoms to which they are bonded, and/or R_2 and R_4 taken together with the carbon and nitrogen atoms to which they are bonded, form a non-aromatic heterocyclic ring optionally fused to an aromatic ring. The remainder of the variables in Structural Formula (I) are as described above.

In a first preferred embodiment, Y in Structural Formula (I), taken together with both $>C=Z$ groups to which it is bonded, is a substituted or unsubstituted arylene group and the compound is represented by Structural Formula (II):



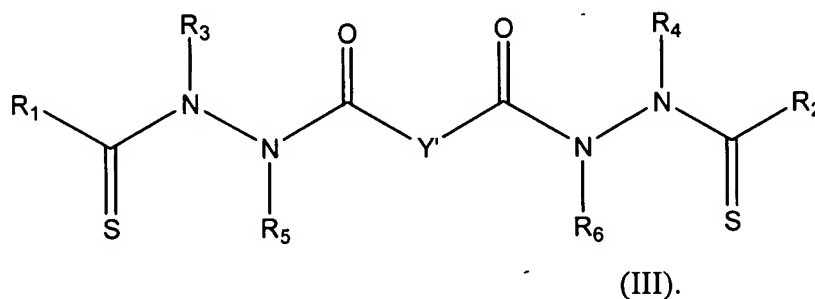
R_1-R_6 in Structural Formula (II) are as described in Structural Formula (I). Ar is a substituted or unsubstituted arylene group. Preferably, Ar is a nitrogen-containing heteroarylene group. Examples are shown below:



Ring A is substituted or unsubstituted.

In a second preferred embodiment, Y in Structural Formula (I) is a covalent bond or a substituted or unsubstituted straight chained hydrocarbyl group. R₇ and R₈ are as described for Structural Formula (I). Preferably, Y is a covalent bond, -C(R₇R₈)-, -(CH₂CH₂)-, *trans*-(CH=CH)-, *cis*-(CH=CH)-, -(CC)- or a 1,4-phenylene group. Even
 5 more preferably, Y is a covalent bond or -C(R₇R₈)-.

In a third preferred embodiment, Y in Structural Formula (I) is a covalent bond or -C(R₇R₈)- and the compound of the present invention is represented by Structural Formula (III):



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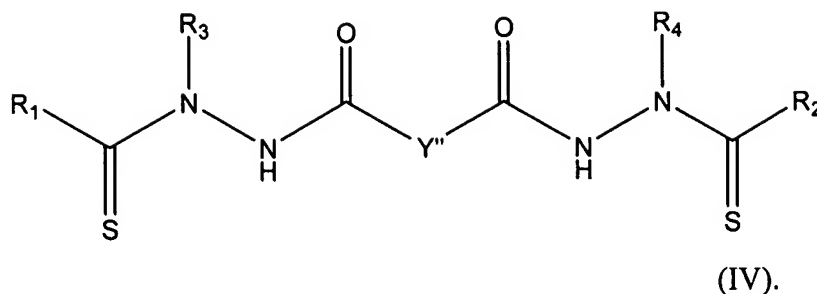
R₁-R₈ are as described for Structural Formula (I). Y' is a covalent bond or -C(R₇R₈)-. Preferably, R₇ and R₈ are both methyl; R₇ and R₈, taken together, are propylene or butylene; or R₇ is -H and R₈ is lower alkyl (preferably methyl), thienyl, phenyl or benzyl.

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In one example of a compound represented by Structural Formula (III), at least one of R₁-R₂ is a substituted aliphatic group, an unsubstituted aliphatic group, a substituted non-aromatic heterocyclic group or an unsubstituted non-aromatic heterocyclic group.

Preferably, R₅-R₈ are all -H. In another example of a compound represented by Structural Formula (III), at least one of R₁-R₂ is an unsubstituted cyclic aliphatic group, a substituted
 20 cyclic aliphatic group, a substituted straight chained or branched aliphatic group, a substituted non-aromatic heterocyclic group, or an unsubstituted non-aromatic heterocyclic group. In these two examples, R₃ and R₄ are preferably methyl.

In a more preferred embodiment, R₅-R₈ in Structural Formula (III) are -H and the compound is represented by Structural Formula (IV):



R₁-R₄ in Structural Formula (IV) are as described in Structural Formula (I). Y'' is a covalent bond or -CH₂-.

- 5 In a first example of a compound represented by Structural Formula (IV), R₃ and R₄ are both a substituted or unsubstituted aliphatic group, preferably both a substituted or unsubstituted lower alkyl group and more preferably both a methyl group or ethyl. When R₃ and R₄ in Structural Formula (IV) are both a substituted or unsubstituted aliphatic group, then: 1) R₁ and R₂ are preferably both a substituted or unsubstituted
- 10 aliphatic group (preferably a substituted or unsubstituted alkyl group and more preferably a C3-C8 substituted or unsubstituted cyclic aliphatic group such as a substituted or unsubstituted cyclopropyl group); or 2) R₁ is preferably a substituted or unsubstituted aliphatic group (preferably a substituted or unsubstituted cyclic aliphatic group); and R₂ is preferably: i) a substituted or unsubstituted aryl group (e.g., a
- 15 substituted or unsubstituted heteroaryl group or a substituted or unsubstituted phenyl group; or ii) an substituted or unsubstituted aliphatic group (preferably a substituted or unsubstituted C3-C8 cyclic aliphatic group).

- In a second example of a compound represented by Structural Formula (IV), R₃ and R₄ are both a substituted or unsubstituted heteroaryl group. When R₃ and R₄ in
- 20 Structural Formula (IV) are both a substituted or unsubstituted heteroaryl group, then: 1) R₁ and R₂ are preferably both a substituted or unsubstituted aliphatic group (preferably a substituted or unsubstituted alkyl group); or 2) R₁ is preferably a substituted or unsubstituted aliphatic group (preferably a substituted or unsubstituted C3-C8 cyclic aliphatic group); and R₂ is preferably: i) a substituted or unsubstituted aryl
- 25 group (e.g., a substituted or unsubstituted heteroaryl group or a substituted or unsubstituted phenyl group; or ii) an substituted or unsubstituted aliphatic group (preferably a substituted or unsubstituted cyclic aliphatic group).

In a third example of a compound represented by Structural Formula (IV), R₃ and R₄ are both a substituted or unsubstituted phenyl group (e.g., a phenyl group substituted with at least one group other than an aliphatic group). When R₃ and R₄ in Structural Formula (IV) are both a substituted or unsubstituted phenyl group, then: 1) R₁ and R₂ are preferably both a substituted or unsubstituted aliphatic group (preferably a substituted or unsubstituted alkyl group and more preferably a C3-C8 substituted or unsubstituted cyclic aliphatic group such as a substituted or unsubstituted cyclopropyl group); or 2) R₁ is preferably a substituted or unsubstituted aliphatic group (preferably a substituted or unsubstituted cyclic aliphatic group); and R₂ is preferably: i) a substituted or unsubstituted aryl group (e.g., a substituted or unsubstituted heteroaryl group or a substituted or unsubstituted phenyl group; or ii) an substituted or unsubstituted aliphatic group (preferably a substituted or unsubstituted cyclic aliphatic group).

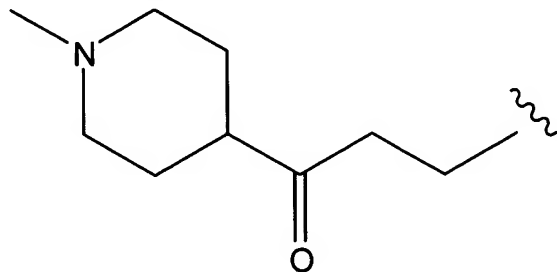
In a fourth example of a compound represented by Structural Formula (IV), R₁ and R₂ are both a substituted or unsubstituted aliphatic group, preferably both a substituted or unsubstituted lower alkyl group, including a C3-C8 cycloalkyl group substituted with at least one lower alkyl group (e.g., methyl, ethyl, *n*-propyl, *n*-butyl, *n*-pentyl, cyclopropyl, 1-methylcyclopropyl, 2-methylcyclopropyl, cyclobutyl, cyclopentyl, or cyclohexyl). When R₁ and R₂ in Structural Formula (IV) are both an aliphatic group or a substituted aliphatic group, then R₃ and R₄ are preferably both: 1) a substituted or unsubstituted aryl group (e.g., a substituted or unsubstituted heteroaryl group, a substituted or unsubstituted phenyl group, or a phenyl group with at least one substituent other than an aliphatic group); or 2) a substituted or unsubstituted aliphatic group (preferably a substituted or unsubstituted alkyl group).

In a fifth example of a compound represented by Structural Formula (IV), R₁ and R₂ are both a substituted or unsubstituted cyclic aliphatic group, preferably both a substituted or unsubstituted cyclopropyl alkyl group.

In a sixth example of a compound represented by Structural Formula (IV), R₁ is a substituted or unsubstituted aliphatic group and R₂ is a substituted or unsubstituted aryl group.

The following are specific examples of compounds represented by Structural Formula (IV): R₁ and R₂ are both methyl, and R₃ and R₄ are both *p*-CF₃-phenyl; R₁ and

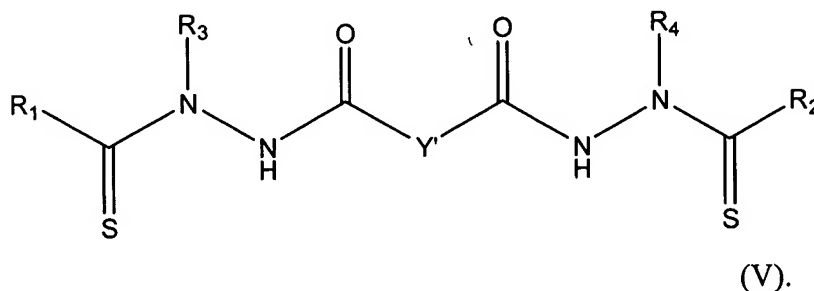
R_2 are both methyl, and R_3 and R_4 are both *o*-CH₃-phenyl; R_1 and R_2 are both -CH₂)₃COOH; and R_3 and R_4 are both phenyl; R_1 and R_2 are both represented by the



following structural formula:

- , and R_3 and R_4 are both phenyl; R_1 and R_2 are both *n*-butyl, and R_3 and R_4 are both phenyl; R_1 and R_2 are both *n*-pentyl, R_3 and R_4 are both phenyl; R_1 and R_2 are both methyl, and R_3 and R_4 are both 2-pyridyl; R_1 and R_2 are both cyclohexyl, and R_3 and R_4 are both phenyl; R_1 and R_2 are both methyl, and R_3 and R_4 are both 2-ethylphenyl; R_1 and R_2 are both methyl, and R_3 and R_4 are both 2,6-dichlorophenyl; R_1 - R_4 are all methyl; R_1 and R_2 are both methyl, and R_3 and R_4 are both *t*-butyl; R_1 and R_2 are both ethyl, and R_3 and R_4 are both methyl; R_1 and R_2 are both *t*-butyl, and R_3 and R_4 are both methyl; R_1 and R_2 are both cyclopropyl, and R_3 and R_4 are both methyl; R_1 and R_2 are both cyclopropyl, and R_3 and R_4 are both ethyl; R_1 and R_2 are both 1-methylcyclopropyl, and R_3 and R_4 are both methyl; R_1 and R_2 are both 2-methylcyclopropyl, and R_3 and R_4 are both methyl; R_1 and R_2 are both 1-phenylcyclopropyl, and R_3 and R_4 are both methyl; R_1 and R_2 are both 2-phenylcyclopropyl, and R_3 and R_4 are both methyl; R_1 and R_2 are both cyclobutyl, and R_3 and R_4 are both methyl; R_1 and R_2 are both cyclopentyl, and R_3 and R_4 are both methyl; R_1 is cyclopropyl, R_2 is phenyl, and R_3 and R_4 are both methyl.

- In a fourth preferred embodiment, Y in Structural Formula (I) is -C(R_7 R₈)- and R_5 and R_6 are both -H. When Y is a covalent bond or -CR₇R₈- and R_5 and R_6 are both -H, the compound of the present invention is represented by Structural Formula (V):



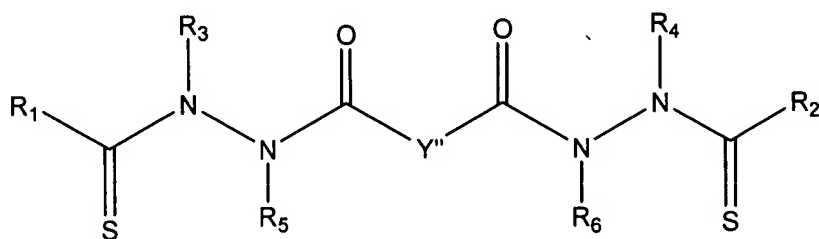
R₁-R₄, R₇ and R₈ are as described for Structural Formula (I) and Y' is a covalent bond or -CR₇R₈-. R₇ and R₈ are the same or different. Preferably, R₇ and R₈ are both methyl; R₇ and R₈, taken together, are propylene or butylene; or R₇ is -H and R₈ is lower alkyl (preferably methyl), thienyl, phenyl or benzyl.

- 5 In one example of a compound represented by Structural Formula (V), R₁ and R₂ are both a lower alkyl group or a substituted lower alkyl group and R₃ and R₄ are both an aryl group or a substituted aryl group. In another example of a compound represented by Structural Formula (V), R₁ and R₂ are both substituted or unsubstituted aliphatic groups and R₃ and R₄ are both a lower alkyl group or a substituted lower alkyl
- 10 group; preferably, R₁ and R₂ are both substituted or unsubstituted alkyl groups (more preferably substituted or unsubstituted cyclic alkyl groups), R₃ and R₄ are both -H, methyl or ethyl, R₇ is -H and R₈ is -H or methyl. In yet another example of a compound represented by Structural Formula (V), R₁ and R₂ are both C3-C8 cyclic alkyl or substituted C3-C8 cyclic alkyl and R₃ and R₄ are both methyl, ethyl, phenyl, or thienyl
- 15 (preferably, R₇ and R₈ are: 1) both methyl; 2) taken together, propylene or butylenes; or 3) R₇ is -H and R₈ is lower alkyl, thienyl, phenyl or benzyl). In yet another example of a compound represented by Structural Formula (V), R₁ and R₂ are both a lower alkyl group or a substituted lower alkyl group and R₃ and R₄ are both methyl, ethyl or phenyl.

- The following are specific examples of compounds represented by Structural
- 20 Formula (V): R₁ and R₂ are both cyclopropyl; R₃ and R₄ are both methyl; R₇ and R₈ are both -H; R₁ and R₂ are both cyclopropyl; R₃ and R₄ are both ethyl; R₇ and R₈ are both -H; R₁ and R₂ are both cyclopropyl; R₃ and R₄ are both methyl; R₇ is methyl; R₈ is -H; R₁ and R₂ are both 1-methylcyclopropyl; R₃ and R₄ are both methyl; Y' is bond; R₁ and R₂ are both 1-methylcyclopropyl; R₃ and R₄ are both methyl; R₇ and R₈ are both -H; R₁ and R₂ are both 1-methylcyclopropyl; R₃ and R₄ are both methyl; R₇ is methyl and R₈ is -H; R₁ and R₂ are both 1-methylcyclopropyl; R₃ and R₄ are both methyl; R₇ is ethyl and R₈ is -H; R₁ and R₂ are both 1-methylcyclopropyl; R₃ and R₄ are both methyl; R₇ is *n*-propyl and R₈ is -H; R₁ and R₂ are both 1-methylcyclopropyl; R₃ and R₄ are both methyl; R₇ and R₈ are both methyl; R₁ and R₂ are both 1-methylcyclopropyl; R₃ and R₄ are both ethyl; R₇ and R₈ are both -H; R₁ and R₂
- 25 1-methylcyclopropyl; R₃ and R₄ are both methyl; R₇ is methyl and R₈ is -H; R₁ and R₂ are both 1-methylcyclopropyl; R₃ and R₄ are both methyl; R₇ is ethyl and R₈ is -H; R₁ and R₂ are both 1-methylcyclopropyl; R₃ and R₄ are both methyl; R₇ is *n*-propyl and R₈ is -H; R₁ and R₂ are both 1-methylcyclopropyl; R₃ and R₄ are both methyl; R₇ and R₈ are both methyl; R₁ and R₂ are both 1-methylcyclopropyl; R₃ and R₄ are both ethyl; R₇ and R₈ are both -H; R₁ and R₂
- 30 are both 1-methylcyclopropyl; R₃ is methyl, and R₄ is ethyl; R₇ and R₈ are both -H; R₁ and R₂ are both 2-methylcyclopropyl; R₃ and R₄ are both methyl; R₇ and R₈ are both -H; R₁ and

- R₂ are both 2-phenylcyclopropyl; R₃ and R₄ are both methyl; R₇ and R₈ are both -H; R₁ and R₂ are both 1-phenylcyclopropyl; R₃ and R₄ are both methyl; R₇ and R₈ are both -H; R₁ and R₂ are both cyclobutyl; R₃ and R₄ are both methyl; R₇ and R₈ are both -H; R₁ and R₂ are both cyclopentyl; R₃ and R₄ are both methyl; R₇ and R₈ are both -H; R₁ and R₂ are both cyclohexyl; R₃ and R₄ are both methyl; R₇ and R₈ are both -H; R₁ and R₂ are both cyclohexyl; R₃ and R₄ are both phenyl; R₇ and R₈ are both -H; R₁ and R₂ are both methyl; R₃ and R₄ are both methyl; R₇ and R₈ are both -H; R₁ and R₂ are both methyl; R₃ and R₄ are both *t*-butyl; R₇ and R₈ are both -H; R₁ and R₂ are both methyl; R₃ and R₄ are both phenyl; R₇ and R₈ are both -H; R₁ and R₂ are both *t*-butyl; R₃ and R₄ are both methyl; R₇ and R₈ are both -H; R₁ and R₂ are ethyl; R₃ and R₄ are both methyl; R₇ and R₈ are both -H; R₁ and R₂ are both *n*-propyl; R₃ and R₄ are both methyl; R₇ and R₈ are both -H;

In a fifth preferred embodiment, Y in Structural Formula (I) is a covalent bond or -CH₂-. When Y is a covalent bond or -CH₂-, the compound of the present invention is represented by Structural Formula (VI):



(VI).

R₁-R₆ in Structural Formula (VI) are as described for Structural Formula (I). R₅ and R₆ are the same or different. Y'' is a covalent bond or -CH₂-.

- In one example of a compound represented by Structural Formula (VI), R₅ and R₆ are both a lower alkyl group (preferably methyl) or a phenyl group. When R₅ and R₆ are both a lower alkyl group or a phenyl group, then R₁ and R₂ are preferably both lower alkyl or substituted lower alkyl and R₃ and R₄ are preferably both phenyl or substituted phenyl. Alternatively, when R₅ and R₆ are both a lower alkyl group or a phenyl group, R₁ and R₂ are both a lower alkyl group or a substituted lower alkyl group and R₃ and R₄ are both lower alkyl or substituted lower alkyl.

In Structural Formulas (I)-(VI), R₁ and R₂ are the same (e.g., R₁ and R₂ are both the same substituted or unsubstituted aliphatic group) or different (e.g., R₁ is a substituted or unsubstituted aliphatic group and R₂ is a substituted or unsubstituted aryl

group); and/or R_3 and R_4 are the same or different. Preferably, R_1 and R_2 are the same, and R_3 and R_4 are the same.

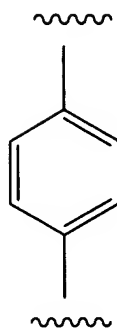
A "straight chained hydrocarbaryl group" is an alkylene group, i.e., $-(CH_2)_x-$, with one or more (preferably one) methylene groups optionally replaced with a linkage group. x is a positive integer (e.g., between 1 and about 10), preferably between 1 and about 6 and more preferably 1 or 2. A "linkage group" refers to a functional group which replaces a methylene in a straight chained hydrocarbaryl. Examples of suitable linkage groups include a ketone ($-C(O)-$), alkene, alkyne, phenylene, ether ($-O-$), thioether ($-S-$), or amine $[-N(R^a)]-$, wherein R^a is defined below. A preferred linkage group is $-C(R_7R_8)-$, wherein R_7 and R_8 are defined above. Suitable substituents for an alkylene group and a hydrocarbaryl group are those which do not substantially interfere with the reactions described herein. R_7 and R_8 are preferred substituents for an alkylene or hydrocarbaryl group.

An aliphatic group is a straight chained, branched or cyclic non-aromatic hydrocarbon which is completely saturated or which contains one or more units of unsaturation. Typically, a straight chained or branched aliphatic group has from 1 to about 20 carbon atoms, preferably from 1 to about 10, and a cyclic aliphatic group has from 3 to about 10 carbon atoms, preferably from 3 to about 8. An aliphatic group is preferably a straight chained or branched alkyl group, e.g., methyl, ethyl, *n*-propyl, *iso*-propyl, *n*-butyl, *sec*-butyl, *tert*-butyl, pentyl, hexyl, pentyl or octyl, or a cycloalkyl group with 3 to about 8 carbon atoms, e.g., cyclopropyl, clobutyl, cyclopentyl, cyclohexyl, or cyclooctyl. A C1-C20 straight chained or branched alkyl group or a C3-C8 cyclic alkyl group is also referred to as a "lower alkyl" group.

Aromatic groups include carbocyclic aromatic groups such as phenyl, naphthyl, and anthracyl, and heteroaryl groups such as imidazolyl, thienyl, furanyl, pyridyl, pyrimidy, pyranal, pyrazolyl, pyrrolyl, pyrazinyl, thiazole, oxazolyl, and tetrazole.

Aromatic groups also include fused polycyclic aromatic ring systems in which a carbocyclic aromatic ring or heteroaryl ring is fused to one or more other heteroaryl rings. Examples include benzothienyl, benzofuranyl, indolyl, quinolinyl, benzothiazole, benzooxazole, benzimidazole, quinolinyl, isoquinolinyl and isoindolyl.

The term "arylene" refers to an aryl group which is connected to the remainder of the molecule by two other bonds. By way of example, the structure of a 1,4-phenylene group is shown below:



Substituents for an arylene group are as described below for an aryl group.

Non-aromatic heterocyclic rings are non-aromatic carbocyclic rings which include one or more heteroatoms such as nitrogen, oxygen or sulfur in the ring. The ring can be five, six, seven or eight-membered. Examples include tetrahydrofuranyl, tetrahydrothiophenyl, morpholino, thiomorpholino, pyrrolidinyl, piperazinyl, piperidinyl, and thiazolidinyl.

The terms “lower alkoxy”, “lower acyl”, “(lower alkoxy)methyl” and “(lower alkyl)thiomethyl” mean to -O-(lower alkyl), -C(O)-(lower alkyl), -CH₂-O-(lower alkyl) and -CH₂-S-(lower alkyl), respectively. The terms “substituted lower alkoxy” and “substituted lower acyl” mean -O-(substituted lower alkyl) and -C(O)-(substituted lower alkyl), respectively.

Suitable substituents on an aliphatic group, non-aromatic heterocyclic group, benzylic or aryl group (carbocyclic and heteroaryl) are those which do not substantially interfere with the ability of the disclosed compounds to enhance the anti-cancer activity of taxol and analogs thereof. A substituent substantially interferes with the ability of a disclosed compound to enhance anti-cancer activity when the enhancement is reduced by more than about 50% in a compound with the substituent compared with a compound without the substituent. Examples of suitable substituents include -OH, halogen (-Br, -Cl, -I and -F), -OR^a, -O-COR^a, -COR^a, -CN, -NO₂, -COOH, -SO₃H, -NH₂, -NHR^a, -N(R^aR^b), -COOR^a, -CHO, -CONH₂, -CONHR^a, -CON(R^aR^b), -NHCOR^a, -NRCOR^a, -NHCONH₂, -NHCONR^aH, -NHCON(R^aR^b), -NR^cCONH₂, -NR^cCONR^aH, -NR^cCON(R^aR^b), -C(=NH)-NH₂, -C(=NH)-NHR^a, -C(=NH)-N(R^aR^b), -C(=NR^c)-NH₂, -C(=NR^c)-NHR^a, -C(=NR^c)-N(R^aR^b), -NH-C(=NH)-NH₂, -NH-C(=NH)-NHR^a, -NH-C(=NH)-N(R^aR^b), -NH-C(=NR^c)-NH₂, -NH-C(=NR^c)-NHR^a, -NH-C(=NR^c)-N(R^aR^b), -NR^dH-C(=NH)-NH₂, -NR^d-C(=NH)-NHR^a, -NR^d-C(=NH)-N(R^aR^b), -NR^d-C(=NR^c)-NH₂, -NR^d-C(=NR^c)-NHR^a, -NR^d-C(=NR^c)-N(R^aR^b), -NHNH₂, -NHNHR^a, -NHR^aR^b, -SO₂NH₂, -SO₂NHR^a, -SO₂NR^aR^b, -CH=CHR^a, -CH=CR^aR^b, -CR^c=CR^aR^b, -CR^c=CHR^a, -CR^c=CR^aR^b, -CCR^a,

-SH, $-SO_kR^a$ (k is 0, 1 or 2) and $-NH-C(=NH)-NH_2$. R^a-R^d are each independently an aliphatic, substituted aliphatic, benzyl, substituted benzyl, aromatic or substituted aromatic group, preferably an alkyl, benzylic or aryl group. In addition, $-NR^aR^d$, taken together, can also form a substituted or unsubstituted non-aromatic heterocyclic group.

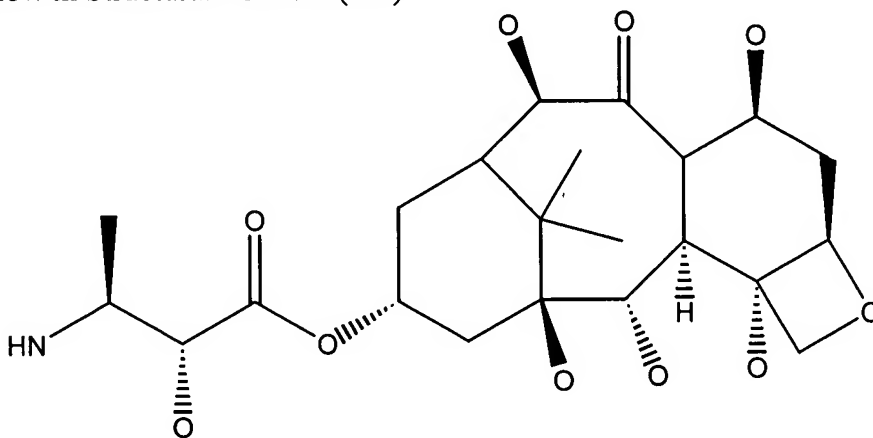
- 5 A non-aromatic heterocyclic group, benzylic group or aryl group can also have an aliphatic or substituted aliphatic group as a substituent. A substituted aliphatic group can also have a non-aromatic heterocyclic ring, a substituted a non-aromatic heterocyclic ring, benzyl, substituted benzyl, aryl or substituted aryl group as a substituent. A substituted aliphatic, non-aromatic heterocyclic group, substituted aryl, 10 or substituted benzyl group can have more than one substituent.

Also included in the present invention are pharmaceutically acceptable salts of the compounds described herein. The compound of the present invention which possess a sufficiently acidic, a sufficiently basic, or both functional groups, and accordingly can react with any of a number of inorganic bases, and inorganic and organic acids, to form 15 a salt. Acids commonly employed to form acid addition salts are inorganic acids such as hydrochloric acid, hydrobromic acid, hydroiodic acid, sulfuric acid, phosphoric acid, and the like, and organic acids such as *p*-toluenesulfonic acid, methanesulfonic acid, oxalic acid, *p*-bromophenyl-sulfonic acid, carbonic acid, succinic acid, citric acid, benzoic acid, acetic acid, and the like. Examples of such salts include the sulfate, 20 pyrosulfate, bisulfate, sulfite, bisulfite, phosphate, monohydrogenphosphate, dihydrogenphosphate, metaphosphate, pyrophosphate, chloride, bromide, iodide, acetate, propionate, decanoate, caprylate, acrylate, formate, isobutyrate, caproate, heptanoate, propiolate, oxalate, malonate, succinate, suberate, sebacate, fumarate, maleate, butyne-1,4-dioate, hexyne-1,6-dioate, benzoate, chlorobenzoate, 25 methylbenzoate, dinitrobenzoate, hydroxybenzoate, methoxybenzoate, phthalate, sulfonate, xylenesulfonate, phenylacetate, phenylpropionate, phenylbutyrate, citrate, lactate, gamma-hydroxybutyrate, glycolate, tartrate, methanesulfonate, propanesulfonate, naphthalene-1-sulfonate, naphthalene-2-sulfonate, mandelate, and the like.

- 30 Base addition salts include those derived from inorganic bases, such as ammonium or alkali or alkaline earth metal hydroxides, carbonates, bicarbonates, and the like. Such bases useful in preparing the salts of this invention thus include sodium hydroxide, potassium hydroxide, ammonium hydroxide, potassium carbonate, and the like.

- 35 Taxol, also referred to as "Paclitaxel", is a well-known anti-cancer drug which acts by inhibiting microtubule formation. Many analogs of taxol are known, including

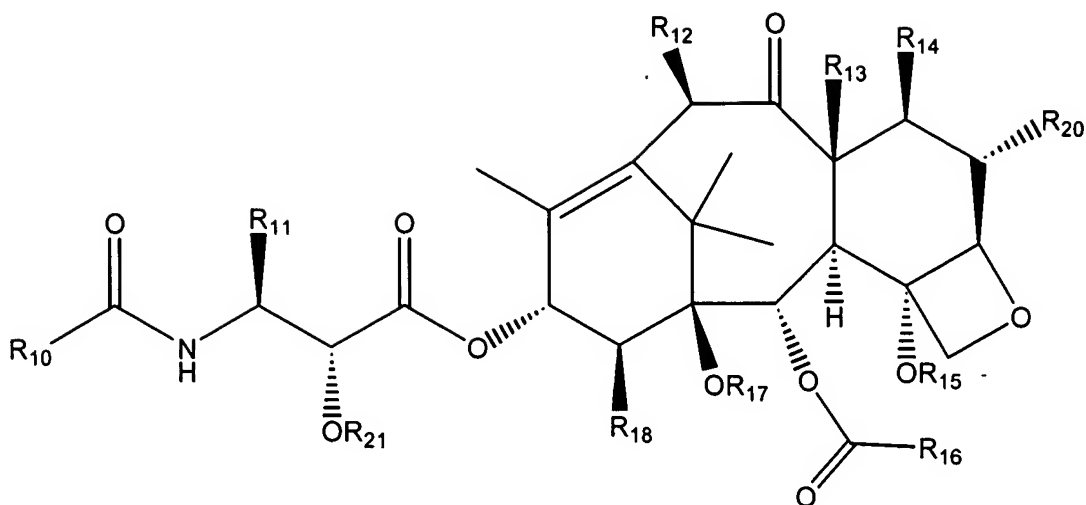
taxotere, the structure of which is shown in Figure 4. Taxotere is also referred to as “Docetaxol”. The structure of other taxol analogs are shown in Figures 5-25. These compounds have the basic taxane skeleton as a common structure feature and have also been shown to have the ability to arrest cells in the G2-M phases due to stabilized microtubules. Thus, it is apparent from Figures 5-25 that a wide variety of substituents can decorate the taxane skeleton without adversely affecting biological activity. It is also apparent that zero, one or both of the cyclohexane rings of a taxol analog can have a double bond at the indicated positions. For clarity purposes, the basic taxane skeleton is shown below in Structural Formula (VII):



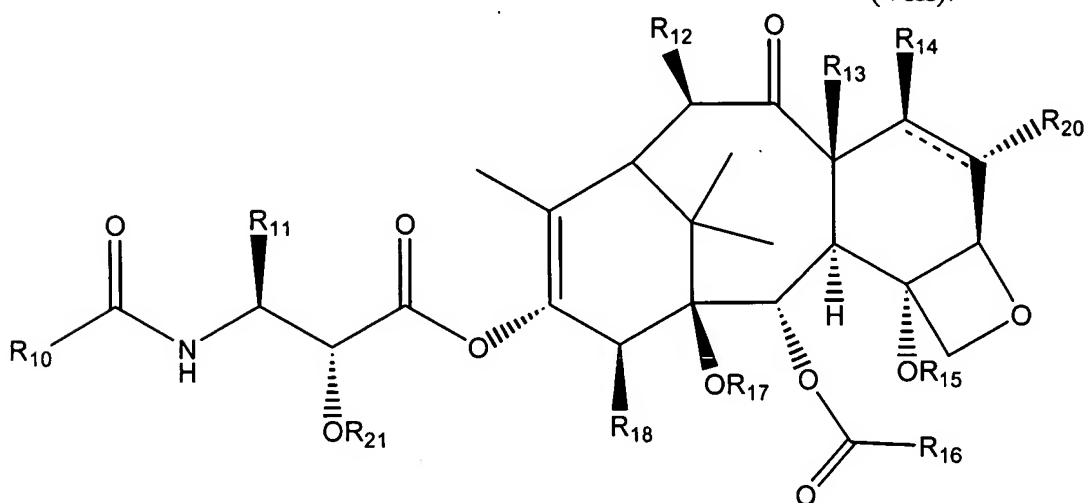
(VII).

Double bonds have been omitted from the cyclohexane rings in the taxane skeleton represented by Structural Formula (VII). It is to be understood that the basic taxane skeleton can include zero or one double bond in one or both cyclohexane rings, as indicated in Figures 5-25 and Structural Formulas (VIII) and (IX) below. A number of atoms have also omitted from Structural Formula (VII) to indicate sites in which structural variation commonly occurs among taxol analogs. For example, substitution on the taxane skeleton with simply an oxygen atom indicates that hydroxyl, acyl, alkoxy or other oxygen-bearing substituent is commonly found at the site. It is to be understood that these and other substitutions on the taxane skeleton can also be made without losing the ability to enhance and stabilize microtubule formation. Thus, the term “taxol analog” is defined herein to mean a compound which has the basic taxol skeleton and which promotes disassembly of microtubules.

Typically, the taxol analogs used herein are represented by Structural Formula (VIII) or (IX):



(VIII).



(IX).

R_{10} is a lower alkyl group, a substituted lower alkyl group, a phenyl group, a substituted phenyl group, $-SR_{19}$, $-NHR_{19}$ or $-OR_{19}$.

R_{11} is a lower alkyl group, a substituted lower alkyl group, an aryl group or a substituted aryl group.

R_{12} is $-H$, $-OH$, lower alkyl, substituted lower alkyl, lower alkoxy, substituted lower alkoxy, $-O-C(O)-(lower\ alkyl)$, $-O-C(O)-(substituted\ lower\ alkyl)$, $-O-CH_2-O-(lower\ alkyl)$ $-S-CH_2-O-(lower\ alkyl)$.

R_{13} is $-H$, $-CH_3$, or, taken together with R_{14} , $-CH_2-$.

R₁₄ is -H, -OH, lower alkoxy, -O-C(O)-(lower alkyl), substituted lower alkoxy, -O-C(O)-(substituted lower alkyl), -O-CH₂-O-P(O)(OH)₂, -O-CH₂-O-(lower alkyl), -O-CH₂-S-(lower alkyl) or, taken together with R₂₀, a double bond.

5 R₁₅ -H, lower acyl, lower alkyl, substituted lower alkyl, alkoxymethyl, alkthiomethyl, -OC(O)-O(lower alkyl), -OC(O)-O(substituted lower alkyl), -OC(O)-NH(lower alkyl) or -OC(O)-NH(substituted lower alkyl).

R₁₆ is phenyl or substituted phenyl.

R₁₇ is -H, lower acyl, substituted lower acyl, lower alkyl, substituted, lower alkyl, (lower alkoxy)methyl or (lower alkyl)thiomethyl.

10 R₁₈ -H, -CH₃ or, taken together with R₁₇ and the carbon atoms to which R₁₇ and R₁₈ are bonded, a five or six membered a non-aromatic heterocyclic ring.

R₁₉ is a lower alkyl group, a substituted lower alkyl group, a phenyl group, a substituted phenyl group.

R₂₀ is -H or a halogen.

15 R₂₁ is -H, lower alkyl, substituted lower alkyl, lower acyl or substituted lower acyl.

Preferably, the variables in Structural Formulas (VIII) and (IX) are defined as follows: R₁₀ is phenyl, *tert*-butoxy, -S-CH₂-CH-(CH₃)₂, -S-CH(CH₃)₃, -S-(CH₂)₃CH₃, -O-CH(CH₃)₃, -NH-CH(CH₃)₃, -CH=C(CH₃)₂ or *para*-chlorophenyl; R₁₁ is phenyl, (CH₃)₂CHCH₂-, -2-furanyl, cyclopropyl or *para*-toluyl; R₁₂ is -H, -OH, CH₃CO- or -(CH₂)₂-*N*-morpholino; R₁₃ is methyl, or, R₁₃ and R₁₄, taken together, are -CH₂-;

R₁₄ is -H, -CH₂SCH₃ or -CH₂-O-P(O)(OH)₂; R₁₅ is CH₃CO-;

R₁₆ is phenyl; R₁₇ -H, or, R₁₇ and R₁₈, taken together, are -O-CO-O-;

25 R₁₈ is -H; R₂₀ is -H or -F; and R₂₁ is -H, -C(O)-CHBr-(CH₂)₁₃-CH₃ or -C(O)-(CH₂)₁₄-CH₃; -C(O)-CH₂-CH(OH)-COOH, -C(O)-CH₂-O-C(O)-CH₂CH(NH₂)-CONH₂, -C(O)-CH₂-O--CH₂CH₂OCH₃ or -C(O)-O-C(O)-CH₂CH₃.

A taxol analog can also be bonded to or be pendent from a pharmaceutically acceptable polymer, such as a polyacrylamide. One example of a polymer of this type is shown in Figure 26. The term "taxol analog", as it is used herein, includes such
30 polymers.

The disclosed compounds are enhancers of the anti-cancer activity of taxol and taxol analogs. A compound enhances the anti-cancer activity of taxol or a taxol analog when the activity of taxol or the taxol analog is greater when administered in combination with the compound than when administered alone. The degree of the
35 increase in activity depends upon the amount of compound administered. The compounds of the present invention can therefore be used in combination with taxol or

taxol analogs to treat subjects with cancers. Examples include colon cancer, pancreatic cancer, melanoma, renal cancer, sarcoma, breast cancer, ovarian cancer, lung cancer, stomach cancer, bladder cancer and cervical cancer.

5 A "subject" is a mammal, preferably a human, but can also be an animal in need of veterinary treatment, e.g., companion animals (e.g., dogs, cats, and the like), farm animals (e.g., cows, sheep, pigs, horses, and the like) and laboratory animals (e.g., rats, mice, guinea pigs, and the like).

10 In order to achieve an enhancement of the anti-cancer activity of taxol and taxol analogs, an effective amount of a compound of the present invention and an effective amount of taxol or analog of taxol are administered to the subject. With respect to taxol or an analog of taxol, an "effective amount" is a quantity in which anti-cancer effects are normally achieved. With respect to a compound of the present invention, an "effective amount" is the quantity in which a greater anti-cancer effect is achieved when the compound is co-administered with taxol or a taxol analog compared with when
15 taxol or the taxol analog is administered alone. The compound and taxol (or taxol analog) can be co-administered to the subject as part of the same pharmaceutical composition or, alternatively, as separate pharmaceutical compositions. When administered as separate pharmaceutical compositions, the compound or the present invention and taxol (or taxol analog) can be administered simultaneously or at different
20 times, provided that the enhancing effect of the compound is retained.

The amount of compound and taxol (or taxol analog) administered to the subject will depend on the type and severity of the disease or condition and on the characteristics of the subject, such as general health, age, sex, body weight and tolerance to drugs. It will also depend on the degree, severity and type of cancer. The
25 skilled artisan will be able to determine appropriate dosages depending on these and other factors. Effective dosages for taxol and taxol analog are well known and typically range from between about 1 mg/mm² per day and about 1000 mg/mm² per day, preferably between about 10 mg/mm² per day and about 500 mg/mm² per day. Effective amounts of a compound of the present invention typically range between
30 about 1 mg/mm² per day and about 10 grams/mm² per day, and preferably between 10 mg/mm² per day and about 5 grams/mm².

The disclosed compounds are administered by any suitable route, including, for example, orally in capsules, suspensions or tablets or by parenteral administration. Parenteral administration can include, for example, systemic administration, such as by
35 intramuscular, intravenous, subcutaneous, or intraperitoneal injection. The compounds can also be administered orally (e.g., dietary), topically, by inhalation (e.g.,

intrabronchial, intranasal, oral inhalation or intranasal drops), or rectally, depending on the type of cancer to be treated. Oral or parenteral administration are preferred modes of administration. Suitable routes of administration of taxol and taxol analogs are well known in the art and include by parenteral administration, as described above for the compounds of the present invention. Suitable routes of administration for taxol and analogs thereof are well known and include *inter alia* parenteral and oral administration.

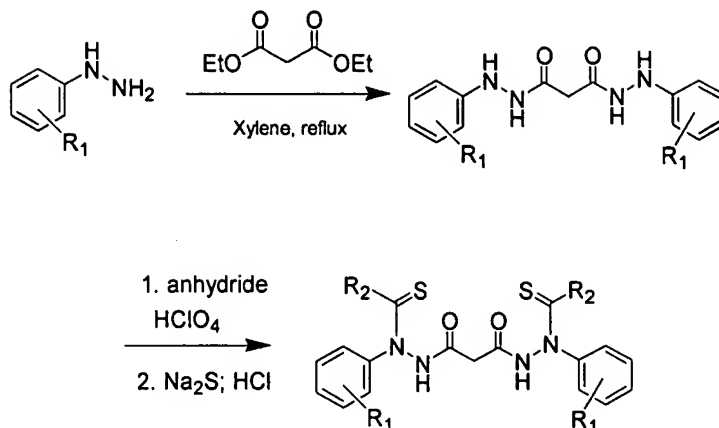
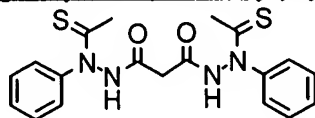
The disclosed compounds can be administered to the subject in conjunction with an acceptable pharmaceutical carrier as part of a pharmaceutical composition for treatment of cancer. Formulation of the compound to be administered will vary according to the route of administration selected (e.g., solution, emulsion, capsule). Suitable pharmaceutical carriers may contain inert ingredients which do not interact with the compound. Standard pharmaceutical formulation techniques can be employed, such as those described in Remington's Pharmaceutical Sciences, Mack Publishing Company, Easton, PA. Suitable pharmaceutical carriers for parenteral administration include, for example, sterile water, physiological saline, bacteriostatic saline (saline containing about 0.9% mg/ml benzyl alcohol), phosphate-buffered saline, Hank's solution, Ringer's-lactate and the like. Methods for encapsulating compositions (such as in a coating of hard gelatin or cyclodextran) are known in the art (Baker, *et al.*, "Controlled Release of Biological Active Agents", John Wiley and Sons, 1986). Suitable formulations for taxol and taxol analogs are well known in the art.

The disclosed compounds can be prepared according to methods described in Examples 1-12 and also according to methods described in the co-pending US Provisional Application entitled SYNTHESIS OF TAXOL ENHANCERS, U.S. Provisional Application No. 60/304,318, filed July 10, 2001. The entire teachings of this application are incorporated herein by reference.

The present invention is illustrated by the following examples, which are not intended to be limiting in any way.

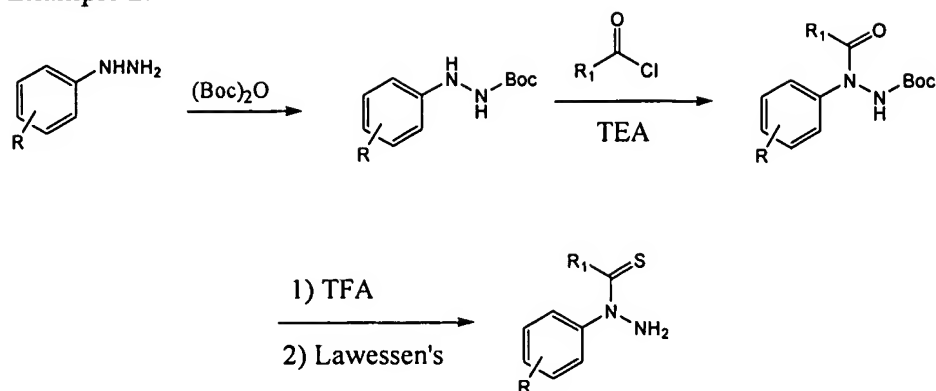
EXEMPLIFICATION

Example 1.

5 Preparation of N-Malonyl-bis[N'-phenyl-N'-(thioacetyl)hydrazide]

- A mixture of phenylhydrazine (30 mL) and ethyl malonate (in xylene (150 mL) was heated to reflux overnight. The reaction was cooled to room temperature. The precipitates were collected via filtration and washed with ethanol to give N-malonyl-bis(N'-phenylhydrazide) as a white solid (14 g). The hydrazide (3.4 g) was suspended in acetic anhydride (30 mL) and cooled in an ice bath. To it was added dropwise perchloric acid (57% in water, 3 mL). The reaction mixture turned to clear solution initially and then quickly solidified. After standing at room temperature for 1 h, ether (50 mL) was added. The resulting slurry was filtered and washed with ether (2 x 00 mL) to give the perchlorate salts as a white solid (5.7 g). The salts were taken into acetone and added as a slurry over 5 min to Na₂S (0.6 M in water, 90 mL) stirred at room temperature. After 30 min, the reaction was acidified with HCl(c) to afford a yellow slurry. The solid was collected via filtration and washed with water (20 mL) and ether (2x25 mL) to give N-malonyl-bis[N'-phenyl-N'-(thioacetyl)hydrazide] as an off-white solid (3.6 g). ¹H NMR (DMSO-d₆): δ 11.5 (m, 2H); 7.5 (m, 10 H); 3.2 (m, 2H); 2.6 (s, 3H); 2.5 (s, 3H). MS calcd (400.1); Found: 423.1 (M+Na)⁺.

Example 2.

Preparation of Thiocyclohexanoic acid N-phenylhydrazide

Phenyl hydrazine (5.4g, 50 mmol) was dissolved in dry dichloromethane (50 mL) in a 250 mL round bottom flask. Di-*tert*-butyl dicarbonate (10.9 g, 50 mmol) was then added with stirring at 0 °C. The resultant solution was then stirred under reflux for 3 h. Removal of the volatile components under reduced pressure afforded a colorless solid, which was washed with hexane and dried in vacuo. 10 g (yield 96%) of the product was obtained as a colorless solid, which can be used in the next step without further purification. 2.5 g (12 mmol) of this material was dissolved in dry pyridine (5 mL). Cyclohexanecarbonyl chloride (2.0 mL, 15 mmol) was then added slowly at 0 °C. The red solution was stirred at 0 °C for half an hour and the resultant yellow suspension was stirred at rt for 3 h before pouring into ice-H₂O (100 mL). The precipitate product was collected by filtration and washed thoroughly with H₂O. After one recrystallization from EtOH/H₂O, 3.63 g (95%) of N-phenyl-N-cyclohexyl-N'-*tert*-butoxycarbonylhydrazide was obtained as a white powder; mp 141-143 °C; ¹H NMR (CDCl₃) δ 0.9-2.3 (m, 11H), 1.4 (s, 9H), 6.9 (br, 1H), 7.4 (m, 5H) ppm.

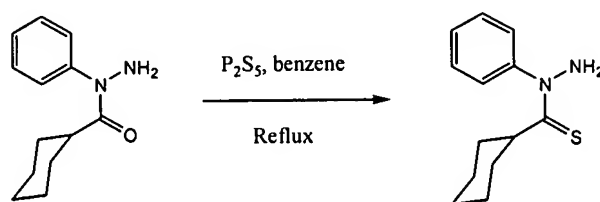
To a solution of N-phenyl-N-cyclohexyl-N'-*tert*-butoxycarbonylhydrazide (1.1 g, 3.46 mmol) in dichloromethane (6 mL) was added trifluoroacetic acid (6 mL) at 0 °C. The resultant solution was stirred at 0 °C for half an hour. Volatile components were then removed under reduced pressure to afford a syrup, which was turned into a solid upon standing; this material was briefly mixed with cold 2 N NaOH (5 mL) for a few minutes at 0 °C. Solid product was then collected by filtration and recrystallized from hexane to afford cyclohexanoic acid N-phenylhydrazide (0.6 g, 80% yield) as a white powder; ¹H NMR (DMSO-*d*₆) δ 0.8-3.2 (m, 1H), 5.3 (s, 2H), 7.0-7.7 (m, 5H); ESMS calcd (C₁₃H₁₈N₂O): 218.3; found: 241.1 (M + Na)⁺.

A mixture of cyclohexanoic acid N-phenylhydrazide (0.25 g, 1.15 mmol) and Lawesson's Reagent (0.46 g, 1.15 mmol) in dry toluene (20 mL) was stirred under

reflux for 1 h. After being cooled to room temperature, the mixture was filtered through a short column of silica gel (5 g) which was pre-washed with benzene. Removal of benzene afforded the crude product as a solid which was purified by column chromatography on silica gel using hexane/EtOAc (4 : 1 v/v) as eluant. 0.15g (60%) of thiocyclohexanoic acid N-phenylhydrazide was obtained as an off white solid. ¹H NMR (CDCl₃) δ 0.8-2.4 (m, 11H), 5.65 (br, 1H), 7.1-7.6 (m, 5H); ESMS calcd (C₁₃H₁₈N₂S): 234.1; found: 235.1 (M+H)⁺.

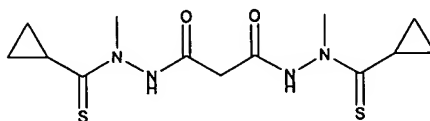
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Example 3.



To a stirred solution of cyclohexanoic acid N-phenylhydrazide (0.1 g, 0.45 mmol) in dry benzene (5 mL) was added P₂S₅ (0.2 g, 0.45 mol). The resultant suspension was heated to reflux for 3 h. After being cooled to room temperature, the mixture was diluted with benzene (5 mL) and was filtered through a short column of silica gel (2 g), washed with benzene and 2:1 hexane/EtOAc (15 mL each). The filtrate and washings were combined and concentrated to afford a solid. Crystallized from hexane to provide the intermediate thiocyclohexanoic acid N-phenylhydrazide as an off white solid; ¹H NMR (CDCl₃) δ 0.8-2.4 (m, 11H), 5.65 (br, 1H), 7.1-7.6 (m, 5H); ESMS calcd (C₁₃H₁₈N₂S): 234.1; found: 235.1 (M+H)⁺.

Example 4.

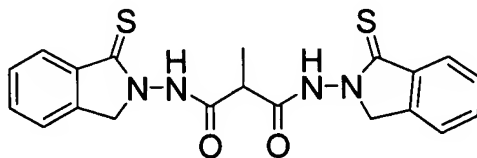


Cyclopropyl bromide (4.8g, 40 mmol) was added into 50 ml anhydrous THF solution containing magnesium powder (1.1g, 45 mmol), stirred for 30 min, and refluxed for another 30 min. After it was cooled, the clear reaction solution was added into carbon disulfide (4 ml, 67 mmol) at 0 °C, and stirred for 30 min at rt. The resulting mixture was then added into

methylhydrazine (8 ml, 150mmol) at 0 °C, and stirred for another 2 hours. To this solution was added water (40 ml) and extracted with EtOAc (60 ml x 3). The organic solution was concentrated to minimum volume, and subjected to silica gel column chromatography (1:1 ethyl acetate: hexanes; ethyl acetate) to give thiocyclopropyl carboxylic acid N¹-methylhydrazide (2.8 g, 55 %). ¹H NMR (300MHz, CDCl₃): δ 5.21 (br., 2H), 3.62 (s, 3H), 1.91 (m, 1H), 1.25 (m, 2H), 0.98 (m, 2H). ESMS calcd (C₅H₁₀N₂S): 130.1; found: 131.1 (M+H)⁺. To the hydrazide EtOAc solution (2.8 g, 22 mmol, 40ml) containing TEA (2.2g, 22mmol) was added malonyl chloride EtOAc solution (1.6g, 11mmol, 4ml) at 0 °C, and the reaction mixture was stirred at rt for 20 min. 20 ml water was added to quench the reaction, and the EtOAc layer was continuously washed twice with water (20 ml x 2). The EtOAc solution was concentrated to minimum volume, and subjected to silica gel column chromatography (eluant: 1:1-1:2 hexanes : ethyl acetate) to give SBR-11-5685 (2.1 g, yield: 60%). (2.1 g, yield: 60%). ¹H NMR (300MHz, CDCl₃): δ 10.01-8.95 (m, 2H), 3.78-3.41(m, 6H), 2.34-0.82 (m, 10H). ESMS calcd(C₁₃H₂₀N₄O₂S₂): 328.1; found: 327 (M-H)⁺.

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Example 5 - Preparation of 2-Methylmalonyl-bis(2-Amino-2,3-dihydro-isoindole-1-thione)

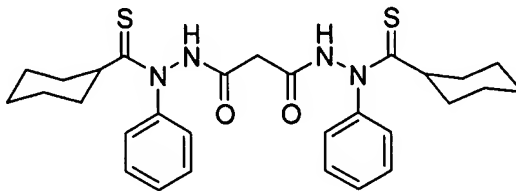


20 2-carboxybenzaldehyde (150 mg, 1mmol) and carbazic acid (132 mg, 1 mmol) in 40 ml methanol was stirred at room temperature for 4 h. To this solution was added Pd/C (60 mg, containing 50 % H₂O), the reaction was under H₂ atmosphere for 3 h. The reaction mixture was filtered, and the solvent was evaporated. The resulting residue was subjected to silica gel column chromatography. (eluent: 20% to 50 %, EtOAc in hexanes) to obtain 50

25 mg of product. ¹H NMR (300MHz, CDCl₃): δ 8.71-7.45 (m, 4H), 4.78 (s, 2H), 1.61(s, 9H). The resulting product was dissolved in CF₃COOH (5ml), stirred for 30 min. The CF₃COOH was evaporated, and the residue was subjected to silica gel column chromatography (eluent: 50% to 0%, hexanes in EtOAc) to give 2-amino-2,3-dihydro-isoindol-1-one (26mg) as a white solid. ¹H NMR (300MHz, CDCl₃): δ 7.85-7.39 (m, 4H), 4.54 (s, 2H). MS: 149 (M+H).

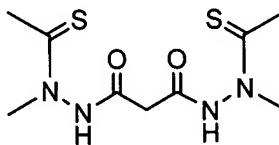
30 Subsequent Lawesson's thiolation and DCC coupling with 2-methylmalonic acid under conditions described above afforded 2-methylmalonyl-bis(2-amino-2,3-dihydro-isoindole-1-thione) as a yellow powder. ¹H NMR (CDCl₃) δ 10.35 (s, 2H), 8.21-7.51(m, 8H), 5.15(s, 4H), 1.62 (s, 3H); ESMS calcd (C₂₀H₁₈N₄O₂S₂): 410.09; found: 411.1 (M+H).

Example 6. The following compounds shown below were prepared by the procedures described above. Analytical data is provided for these compounds.



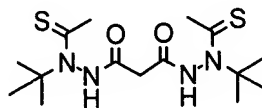
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^1H NMR (DMSO- d_6) δ 0.9-1.8m, (22H), 3.1-3.5 (m, 2H), 7.2-7.6 (m, 10H), 11.1 – 11.7 (ms, 2H) ppm; ESMS calcd ($\text{C}_{29}\text{H}_{36}\text{N}_4\text{O}_2\text{S}_2$): 536.3; found: 537.3(M-H) $^+$.



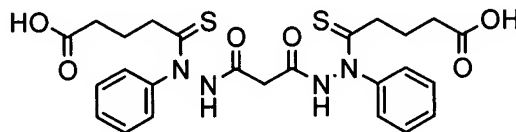
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^1H NMR (CDCl_3): δ 3.6-3.4 (m, 8H), 2.7-2.5 (m, 6H); ESMS calcd for $\text{C}_9\text{H}_{16}\text{N}_4\text{O}_2\text{S}_2$: 276.1; Found: 274.9 (M-H) $^+$.



15

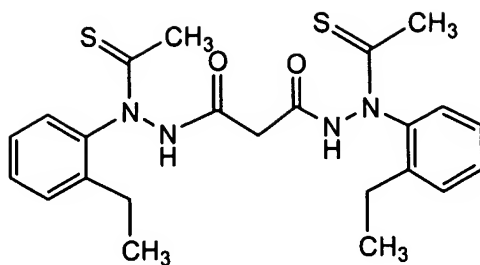
^1H NMR (CDCl_3): δ 2.63 (s, 2H); 2.18 (s, 6H); 1.25 (s, 18H). MS calcd for $\text{C}_{15}\text{H}_{28}\text{N}_4\text{O}_2\text{S}_2$: 360.2; Found: 383.1 (M+Na) $^+$.



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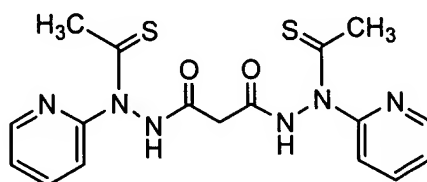
^1H NMR (CDCl_3): δ 7.3 (m, 10H); 3.2 (m, 2H); 2.45 (t, J=7.4 Hz, 4H); 2.21 (t, J=7.4 Hz, 4H); 1.90 (m, 8H). MS calcd for $\text{C}_{25}\text{H}_{28}\text{N}_4\text{O}_6\text{S}_2$: 544.15; Found: 567.2 (M+Na) $^+$.

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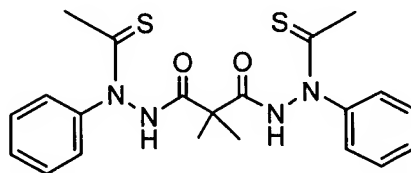
^1H NMR (CDCl_3): δ 7.8-7.4 (br s, 8H), 3.75-3.5 (m, 2H), 3.95-3.8(m, 4H), 2.58 (s, 6H), 1.4 (m, 6H). ESMS calcd for $\text{C}_{23}\text{H}_{28}\text{N}_4\text{O}_2\text{S}_2$: 456.2; Found: 479.2 ($\text{M}+\text{Na}$).

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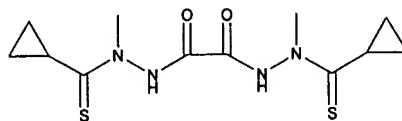
^1H NMR (CDCl_3): δ 8.3-8.05 (m, 4H), 7.75 (t, $J=8.0$ Hz, 2H), 7.1 (br s, 2H), 3.74 (s, 2H), 2.38 (s, 6H). ESMS calcd for $\text{C}_{17}\text{H}_{18}\text{N}_6\text{O}_2\text{S}_2$: 402.1. Found: 403.1 ($\text{M}+\text{H}$) $^+$.

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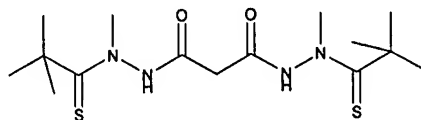
^1H NMR (CDCl_3): δ 7.38 (m, 10 H), 2.40 (s, 6H), 1.5-1.6 (6H); ESMS calcd for $\text{C}_{21}\text{H}_{24}\text{N}_4\text{O}_2\text{S}_2$: 564.1; Found: 565.2 ($\text{M}+\text{H}$) $^+$.

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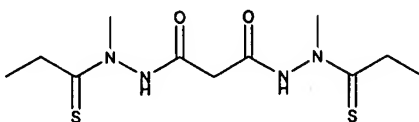


The method was the same as one used in synthesis of 4783, oxalyl chloride was used instead of malonyl dichloride. ^1H NMR (300MHz, DMSO): δ 11.95 (s, 2H), 7.48-7.07(m, 10H), 3.52(s, 6H). ESMS calcd($\text{C}_{18}\text{H}_{18}\text{N}_4\text{O}_2\text{S}_2$):386.09; found: 387 ($\text{M}+\text{H}$) $^+$.

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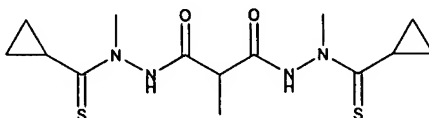


^1H NMR (300MHz, CDCl_3): δ 9.66-8.83 (m, 2H), 3.73-3.23(m, 6H), 2.10-1.20 (m, 20H). ESMS calcd($\text{C}_{15}\text{H}_{28}\text{N}_4\text{O}_2\text{S}_2$):360.17; found: 359 (M-H) $^+$.



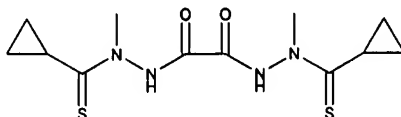
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^1H NMR (300MHz, CDCl_3): δ 3.66-3.42(m, 6H), 2.84-2.58(m, 4H), 1.40-1.19(m, 6H). ESMS calcd($\text{C}_{11}\text{H}_{20}\text{N}_4\text{O}_2\text{S}_2$):304.10; found: 303 (M-H) $^+$.



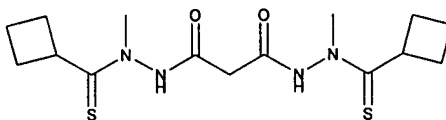
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^1H NMR (300MHz, CDCl_3): δ 4.15-3.40(m, 6H), 2.00-1.01(m, 14H). ESMS calcd($\text{C}_{14}\text{H}_{22}\text{N}_4\text{O}_2\text{S}_2$):342.12; found: 341 (M-H) $^+$.



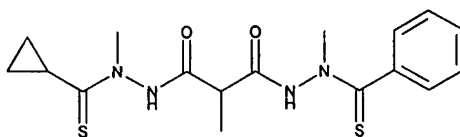
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^1H NMR (300MHz, CDCl_3): δ 3.90-3.18(m, 6H), 2.11-0.91(m, 10H). ESMS calcd($\text{C}_{12}\text{H}_{18}\text{N}_4\text{O}_2\text{S}_2$):314.09; found: 313 (M-H) $^+$.

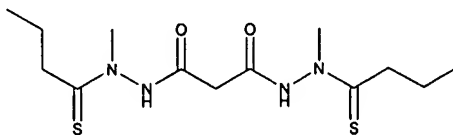


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^1H NMR (300MHz, CDCl_3): δ 10.08-9.01(m, 2H), 3.68-3.20(m, 6H), 2.59-1.12(m, 16H). ESMS calcd($\text{C}_{15}\text{H}_{24}\text{N}_4\text{O}_2\text{S}_2$):356.13; found: 355 (M-H) $^+$.

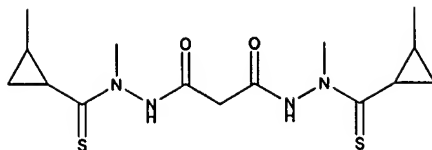


^1H NMR (300MHz, CDCl_3): δ 10.22-9.41(m, 2H), 7.48-7.20(m, 5H), 3.82-3.02(m, 6H), 2.38-0.82(m, 7H). ESMS calcd($\text{C}_{16}\text{H}_{20}\text{N}_4\text{O}_2\text{S}_2$): 364.10; found: 363 (M-H) $^+$.

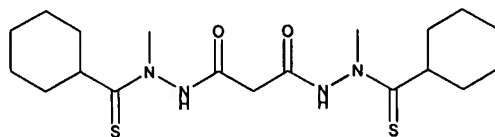


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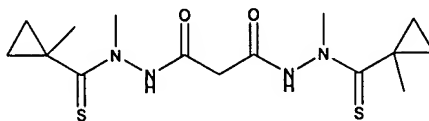
^1H NMR (300MHz, CDCl_3): δ 10.03-9.02(m, 2H), 3.71-3.42(m, 6H), 2.80-0.81(m, 16H). ESMS calcd($\text{C}_{13}\text{H}_{24}\text{N}_4\text{O}_2\text{S}_2$): 332.13; found: 331 (M-H) $^+$.



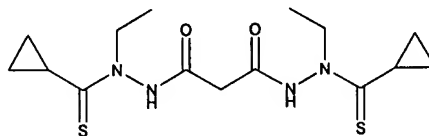
¹H NMR (300MHz, CDCl₃): δ 3.78-3.08(m, 6H), 1.90-0.81(m, 18H). ESMS calcd(C₁₅H₂₄N₄O₂S₂): 356.13; found: 355 (M-H)⁺.



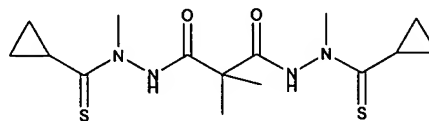
5 ¹H NMR (300MHz, CDCl₃): δ 10.00-8.79(m, 2H), 3.65-3.07(m, 6H), 2.79-1.08(m, 24H). ESMS calcd(C₁₉H₃₂N₄O₂S₂): 412.20; found: 411 (M-H)⁺.



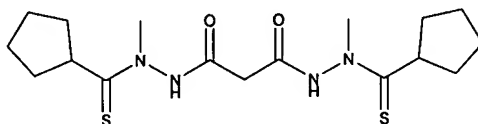
10 ¹H NMR (300MHz, CDCl₃): δ 9.79(br, 2H), 3.79-3.41(m, 6H), 1.60-0.75(m, 18H). ESMS calcd(C₁₅H₂₄N₄O₂S₂): 356.13; found: 355 (M-H)⁺.



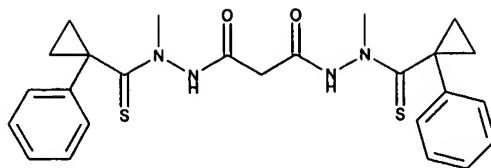
15 ¹H NMR (300MHz, CDCl₃): δ 10.03-9.14(m, 2H), 4.21-3.39(m, 4H), 2.20-0.76(m, 18H). ESMS calcd(C₁₅H₂₄N₄O₂S₂): 356.13; found: 355 (M-H)⁺.



20 ¹H NMR (300MHz, CDCl₃): δ 7.57(br, 2H), 3.72(s, 6H), 2.95(m, 6H), 1.96-0.81(m, 10H). ESMS calcd(C₂₁H₃₆N₄O₂S₂): 440.13; found: 439 (M-H)⁺.

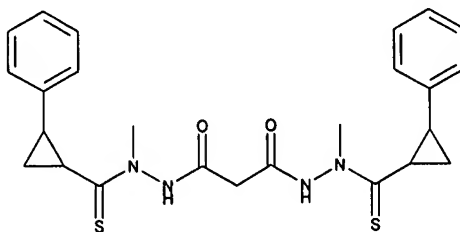


25 ¹H NMR (300MHz, CDCl₃): δ 10.09-8.95(m, 2H), 3.78-3.05(m, 6H), 2.04-1.22(m, 20H). ESMS calcd(C₁₇H₂₈N₄O₂S₂): 384.17; found: 383 (M-H)⁺.



^1H NMR (300MHz, CDCl_3): δ 10.09-8.51(m, 2H), 7.41-7.01(m, 10H), 3.62-3.02(m, 6H), 1.78-1.03(m, 10H). ESMS calcd($\text{C}_{25}\text{H}_{28}\text{N}_4\text{O}_2\text{S}_2$): 480.17; found: 479 (M-H) $^+$.

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^1H NMR (300MHz, CDCl_3): δ 10.09-8.81(m, 2H), 7.51-7.11(m, 10H), 3.80-3.06(m, 6H), 2.92-1.53(m, 10H). ESMS calcd($\text{C}_{25}\text{H}_{28}\text{N}_4\text{O}_2\text{S}_2$): 480.17; found: 479 (M-H) $^+$.

10 Example 7

Compound (1) Enhances the Anti-Cancer Activity of Paclitaxel *in vivo* (Human xenograft model: Human Breast Carcinoma MDA-435 in nude mice)

15 General Procedure of *in vivo* Anti-Tumor Study

The *in vivo* anti-cancer enhancing effect of novel compounds was assessed in tumor bearing mice using the tumor growth inhibition assay. Tumor cells were implanted by injection of a tumor cell suspension subcutaneously in the flank of a mouse. Treatment of the tumor with an experimental compound and Paclitaxel began after the tumor had been established (volume was about 150 mm³). Animal then begun a multiple injection schedule where the compound and Paclitaxel were given by IV route of administration. Tumors were measured two times a week. During the course of this assay, animals were monitored daily for signs of toxicity including body weight loss.

25 Detailed Procedure of MDA-435 (Human Breast Carcinoma) Anti-Tumor Study

A supplemented media was prepared from 50% DMEM/Dulbecco Modified Eagle Medium (High Glucose), 50% RPMI 1640, 10% FBS/Fetal Bovine Serum (Hybridoma Tested; Sterile Filtered), 1% L-Glutamine, 1% Penicillin-Streptomycin, 1% MEM Sodium Pyruvate and 1% MEM Non-Essential Amino Acids. FBS was obtained from Sigma Chemical Co. and other ingredients were obtained from Invitrogen Life Technologies, USA). The

supplemental media was warmed to 37° C and 50 ml of media was added to a 175 cm² tissue culture flask.

The cells used in the assay were MDA-435 Human Breast Carcinoma from the American Type Culture Collection. 1 vial of MDA-435 cells from the liquid nitrogen frozen cell stock was removed. The frozen vial of cells was immediately placed into a 37° C water bath and gently swirled until thawed. The freeze-vial was wiped with 70% ethanol and cells were immediately pipetted into the 175 cm² tissue culture flask containing supplemented media. The cells were incubated overnight and the media was removed and replaced with fresh supplemented media the next day. The flask was incubated until flask became about 90% confluent. This took anywhere from 5-7 days.

The flask was washed with 10 ml of sterile room temperature phosphate buffered saline (PBS). The cells were trypsinized by adding 5 ml of warmed Trypsin-EDTA (Invitrogen) to the flask of cells. The cells were then incubated for 2-3 minutes at 37° C until cells begun to detach from the surface of the flask. An equal volume of supplemented media (5 ml) was added to the flask. All the cells were collected into 50 ml tube, and centrifuged at 1000 RPM for 5 minutes at 20° C. The supernatant was aspirated and the cell pellet was resuspended in 10 ml of supplemented media and the cells were counted. 1-3 million cells/flask were seeded into 5-7 tissue culture flasks (175 cm²). Each flask contained 50 ml of supplemented media. The flasks were incubated until about 90% confluent. The passaging of the cells was repeated until enough cells have been grown for tumor implantation.

The above procedure for trypsinizing and centrifuging the cells were followed. The supernatant was aspirated and the cell pellet was resuspended in 10 ml of sterile PBS and the cells were counted. The cells were centrifuged and then resuspended with appropriate volume of sterile PBS for injection of correct number of cells needed for tumor implantation. In the case of MDA-435, 100 million cells were suspended with 2.0 ml of sterile PBS to a final concentration of 50 million cells/ml in order to inject 5 million cells in 0.1 ml/mouse.

Mice (CD-1 nu/nu) were obtained from Charles River Laboratories: nomenclature: Crl:CD-1-nuBR, Age: 6-8 weeks. The mice were allowed to acclimate for 1 week prior to their being used in an experimental procedure.

Implantation of the MDA-435 tumor cell suspension took place into the corpus adiposum of the female CD-1 nu/nu mouse. This fat body is located in the ventral abdominal viscera of the mouse. Tumor cells were implanted subcutaneously into the fat body located in the right quadrant of the abdomen at the juncture of the os coxae (pelvic bone) and the os femoris (femur). 5 million MDA-435 cells in 0.1 ml of sterile PBS were injected using 27 G (1/2 inch) needle. MDA-435 tumors developed 2-3 weeks after implantation.

Compound stock solutions were prepared by dissolving the compound in a 50:50 mixture of EtOH and Cremophor EL (Polyoxyl 35 Castor Oil, BASF, Germany). This stock solution in 50%EtOH / 50%CrEL was sonicated in an ultrasonic water bath until all the powder dissolved.

- 5 Preparation of Dosing Solution for Compound Administration: The compound stock solution was diluted 1:10 with D5W (5% Dextrose in Water, Abbott Laboratories, USA). :
- 1) 2.0 ml of 2.5 mg/ml dosing solution of Compound (1) was prepared by diluting 0.2 ml of a 25 mg/ml Compound Stock solution with 1.8 ml of 100% D5W; and 2) a dosing solution comprising of 1.5 mg/ml of Paclitaxel (obtained from Sigma Chemical Co.) and 2.5 mg/ml
- 10 of Compound (1) was obtained by mixing 0.2 ml of a 50%EtOH/ 50% CrEL stock solution containing 25 mg/ml of Compound (1) and 15 mg/ml of Paclitaxel with 1.8 ml of a 100% D5W solution. The final formulation for the dosing solution was 5% EtOH, 5% CrEL, 4.5 % Dextrose, and 85.5% water.
- 15 The Dosing Solution (Dosing Volume: 0.01 ml/gram = 10 ml/ kg) was injected intravenously into the mice bearing MDA-435 human breast tumor.

PROTOCOL

- 20 Mice: CD-1 nu/nu female (n=5/group)
 Tumor: MDA-435 (Human breast carcinoma)
 Implantation: 5×10^6 cells/mouse
 Formulation: 5% Cremophor EL, 5% ethanol, and 4.5 % glucose water solution
 Administration route: intravenous bolus injection
- 25 Dosing schedule: weekly x 4

Group	Drug Treatment (Dose)
1	Vehicle Only
2	Paclitaxel (15 mg/kg)
3	Compound (1) (25 mg/kg)
4	Paclitaxel (15 mg/kg) + Compound (1) (25 mg/kg)

RESULTS

Figure 1 shows the effects of Compound (1) on enhancing anti-tumor activity of Paclitaxel (Taxol). As can be seen from Figure 1, Compound (1) significantly enhanced anti-tumor activity of Paclitaxel on human breast tumor MDA-435 in nude mice. Figure 2 shows the effects of Compound (1) and Paclitaxel on the body weight of nude mice bearing MDA-435 human breast tumor. As can be seen from Figure 2, Compound (1) significantly enhanced anti-tumor activity of Paclitaxel without increasing toxicity.

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While this invention has been particularly shown and described with references to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the scope of the invention encompassed by the appended claims.